

APPENDIX A

Land Use Distribution in the South Fork Holston River Watershed

Table A-1. MRLC Land Use Distribution of S. Fork Holston River Subwatersheds

Land Use	HUC-12 Subwatershed (06010102__) or Drainage Area					
	Waters Branch DA		Laurel Creek DA		Paint Springs Branch DA	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Bare Rock/Sand/Clay	0.0	0.0	1.3	0.0	0.0	0.0
Deciduous Forest	0.7	0.1	30.0	0.1	57.5	41.5
Emergent Herbaceous Wetlands	0.0	0.0	1.1	0.0	0.0	0.0
Evergreen Forest	0.0	0.0	3.3	0.0	25.2	18.2
High Intensity Commercial/Industrial/Transp.	0.2	0.0	4.4	0.0	0.0	0.0
High Intensity Residential	0.0	0.0	0.0	0.0	0.0	0.0
Low Intensity Residential	12.2	2.2	140.6	0.6	0.0	0.0
Mixed Forest	168.1	29.7	10,477.1	47.6	13.6	9.8
Open Water	103.9	18.4	3,528.1	16.0	0.0	0.0
Other Grasses (Urban/recreation; e.g. parks)	171.0	30.2	4,458.1	20.2	0.0	0.0
Pasture/Hay	97.2	17.2	2,656.3	12.1	38.8	28.0
Quarries/Strip Mines/Gravel Pits	12.0	2.1	705.0	3.2	0.0	0.0
Row Crops	0.4	0.1	6.4	0.0	3.5	2.5
Transitional	0.0	0.0	3.3	0.0	0.0	0.0
Woody Wetlands	0.0	0.0	1.6	0.0	0.0	0.0
Total	565.8	100.0	22,016.7	100.0	138.7	100.0

Note: Percent calculations were performed using a spreadsheet. Percentages and totals were rounded off and may differ slightly from values calculated by other means.

Table A-1 (Cont.). MRLC Land Use Distribution of S. Fork Holston River Subwatersheds

Land Use	HUC-12 Subwatershed (06010102__) or Drainage Area					
	0401		Big Arm Branch DA		Dry Creek DA	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Bare Rock/Sand/Clay	68.7	0.2	1.8	0.1	7.8	0.1
Deciduous Forest	11,507.2	36.8	1,343.5	66.0	2,735.9	49.3
Emergent Herbaceous Wetlands	12.9	0.0	0.0	0.0	0.0	0.0
Evergreen Forest	4,082.1	13.1	283.1	13.9	1,050.4	18.9
High Intensity Commercial/Industrial/Transp.	365.6	1.2	2.0	0.1	5.1	0.1
High Intensity Residential	86.3	0.3	0.0	0.0	1.3	0.0
Low Intensity Residential	1,818.1	5.8	26.0	1.3	68.3	1.2
Mixed Forest	3,649.1	11.7	303.8	14.9	1,092.6	19.7
Open Water	203.3	0.7	0.9	0.0	0.0	0.0
Other Grasses (Urban/recreation; e.g. parks)	274.2	0.9	4.7	0.2	3.6	0.1
Pasture/Hay	7,919.7	25.4	56.0	2.8	497.1	9.0
Quarries/Strip Mines/Gravel Pits	4.0	0.0	0.0	0.0	0.0	0.0
Row Crops	1,163.6	3.7	13.6	0.7	78.5	1.4
Transitional	0.9	0.0	0.0	0.0	0.0	0.0
Woody Wetlands	75.2	0.2	0.4	0.0	4.2	0.1
Total	31,230.8	100.0	2,035.8	100.0	5,544.8	100.0

Note: Percent calculations were performed using a spreadsheet. Percentages and totals were rounded off and may differ slightly from values calculated by other means.

Table A-1 (Cont.). MRLC Land Use Distribution of S. Fork Holston River Subwatersheds

Land Use	HUC-12 Subwatershed (06010102__) or Drainage Area					
	Woods Branch DA		UT2 to SFHOL DA		0403	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Bare Rock/Sand/Clay	0.7	0.1	1.6	0.3	145.9	0.4
Deciduous Forest	70.7	7.7	70.1	14.1	8,285.6	25.4
Emergent Herbaceous Wetlands	10.7	1.2	0.0	0.0	49.4	0.2
Evergreen Forest	28.7	3.1	77.4	15.6	3,794.1	11.7
High Intensity Commercial/Industrial/Transp.	9.6	1.0	1.1	0.2	669.0	2.1
High Intensity Residential	0.0	0.0	0.0	0.0	57.6	0.2
Low Intensity Residential	0.0	0.0	14.9	3.0	1,459.4	4.5
Mixed Forest	291.6	31.6	59.6	12.0	3,530.5	10.8
Open Water	107.2	11.6	0.2	0.0	1,288.6	4.0
Other Grasses (Urban/recreation; e.g. parks)	111.4	12.1	13.3	2.7	847.1	2.6
Pasture/Hay	184.4	20.0	236.2	47.6	10,708.4	32.9
Quarries/Strip Mines/Gravel Pits	89.0	9.6	0.0	0.0	0.0	0.0
Row Crops	11.8	1.3	20.2	4.1	1,554.1	4.8
Transitional	6.0	0.7	0.0	0.0	0.0	0.0
Woody Wetlands	2.0	0.2	1.1	0.2	173.0	0.5
Total	923.6	100.0	495.7	100.0	32,562.5	100.0

Note: Percent calculations were performed using a spreadsheet. Percentages and totals were rounded off and may differ slightly from values calculated by other means.

Table A-1 (Cont.). MRLC Land Use Distribution of S. Fork Holston River Subwatersheds

Land Use	HUC-12 Subwatershed (06010102__) or Drainage Area	
	0502	
	[acres]	[%]
Bare Rock/Sand/Clay	111.0	0.3
Deciduous Forest	14,712.6	36.6
Emergent Herbaceous Wetlands	27.1	0.1
Evergreen Forest	4,283.6	10.7
High Intensity Commercial/Indus trial/Transp.	1,475.8	3.7
High Intensity Residential	670.5	1.7
Low Intensity Residential	4,942.1	12.3
Mixed Forest	4,432.1	11.0
Open Water	137.7	0.3
Other Grasses (Urban/recreation; e.g. parks)	1,212.3	3.0
Pasture/Hay	7,080.2	17.6
Quarries/Strip Mines/Gravel Pits	0.2	0.0
Row Crops	1,009.0	2.5
Transitional	0.0	0.0
Woody Wetlands	105.4	0.3
Total	40,199.6	100.0

Note: Percent calculations were performed using a spreadsheet. Percentages and totals were rounded off and may differ slightly from values calculated by other means.

APPENDIX B

Water Quality Monitoring Data

There are a number of water quality monitoring stations that provide data for waterbodies identified as impaired for E. coli in the South Fork Holston River Watershed. The location of these monitoring stations is shown in Figure 5. Monitoring data recorded by TDEC at these stations are tabulated in Table B-1.

Table B-1. TDEC Water Quality Monitoring Data – South Fork Holston River Subwatersheds

Monitoring Station	Date	E. Coli
		[cts./100 mL]
BACK000.5SU	7/17/02	>2419
	8/20/02	1300
	9/11/02	727
	10/23/02	1733
	11/13/02	1553
	12/3/02	866
	9/9/99	866
	1/15/03	548
	2/18/03	326
	3/12/03	29
	4/15/03	411
	5/12/03	816
	6/25/03	921
	7/17/02	921
BACK003.1SU	8/20/02	770
	9/11/02	236
	10/23/02	249
	11/13/02	613
	12/3/02	144
	1/15/03	40
	2/18/03	291
	3/12/03	91
	4/15/03	488
	5/12/03	344
	6/25/03	727
	9/19/02	>2420
BARM000.1CT	10/17/02	>2420
	11/26/02	71
	12/17/02	99

Table B-1 (Cont.). TDEC Water Quality Monitoring Data – South Fork Holston Subwatersheds

Monitoring Station	Date	E. Coli
		[cts./100 mL]
BARM000.1CT (cont'd)	1/22/03	118
	3/5/03	201
	3/25/03	40
	4/30/03	1300
	6/17/03	649
BEAVE001.0SU	3/3/98	299
	6/25/98	>2419
	9/17/98	24
	12/15/98	1120
	3/2/99	179
	6/15/99	249
	9/7/99	11
	12/2/99	166
	2/17/00	89
	5/11/00	152
	8/10/00	2419
	11/28/00	517
	3/7/01	249
	6/26/01	144
	7/17/01	5
	10/9/01	285
	4/16/02	299
	7/17/02	727
	8/20/02	1553
	9/11/02	185
	10/23/02	461
	11/13/02	>2419
	12/3/02	649
	1/15/03	17
	2/18/03	687
	3/12/03	345
	4/15/03	770
	5/12/03	1203
	6/25/03	866

Table B-1 (Cont.). TDEC Water Quality Monitoring Data – South Fork Holston Subwatersheds

Monitoring Station	Date	E. Coli
		[cts./100 mL]
BEAVE001.0SU (cont'd)	8/12/03	>2419
	11/4/03	130
	8/4/04	1414
	11/4/04	2000
BEAVE009.7JO	7/10/02	102
BEAVE011.0SU	7/17/02	921
	8/20/02	980
	9/11/02	613
	10/23/02	326
	11/13/02	1986
	12/3/02	980
	1/15/03	1553
	2/18/03	1986
	3/12/03	2419
	4/15/03	1300
	5/12/03	866
	6/25/03	1414
BEAVE014.0JO	7/10/02	96
BEAVE015.3SU	3/3/98	548
	6/25/98	1553
	9/17/98	>2419
	12/15/98	1046
	3/2/99	326
	6/15/99	1046
	9/7/99	1414
	12/2/99	461
	2/17/00	1046
	5/11/00	1553
	8/10/00	1986
	11/28/00	308
	3/7/01	1553
	6/26/01	1300
	7/17/01	613
	10/9/01	>2419
	4/16/02	>2419
	7/17/02	>2419

Table B-1 (Cont.). TDEC Water Quality Monitoring Data – South Fork Holston Subwatersheds

Monitoring Station	Date	E. Coli
		[cts./100 mL]
BEAVE015.3SU (cont'd)	8/20/02	>2419
	9/11/02	>2419
	10/23/02	>2419
	11/13/02	2419
	12/3/02	>2419
	1/15/03	144
	2/18/03	649
	3/12/03	1733
	4/15/03	1986
	5/12/03	>2419
	6/25/03	>2419
	8/12/03	>2419
	11/4/03	2419
	8/4/04	>2419
	11/4/04	2600
BEAVE015.7JO	7/10/02	6
BEAVE016.7JO	7/10/02	1
BOOHE000.3SU	9/19/02	1986
	10/17/02	1414
	11/26/02	546
	12/17/02	272
	1/22/03	99
	3/5/03	108
	3/25/03	166
	4/30/03	>2420
	6/17/03	1046
CANDY001.7SU	9/19/02	>2420
	10/17/02	517
	11/26/02	816
	12/17/02	1986
	1/22/03	387
	3/5/03	64
	3/25/03	649
	5/1/03	1733
	6/17/03	1553

Table B-1 (Cont.). TDEC Water Quality Monitoring Data – South Fork Holston Subwatersheds

Monitoring Station	Date	E. Coli
		[cts./100 mL]
CEDAR000.3SU	9/9/99	980
	7/17/02	548
	8/20/02	770
	9/11/02	770
	10/23/02	1414
	11/13/02	921
	12/3/02	387
	1/15/03	770
	2/18/03	1300
	3/12/03	31
	4/15/03	313
	5/12/03	687
	6/25/03	308
DRY000.2SU	10/24/02	>2420
	11/25/02	>2420
	12/16/02	>2420
	1/21/03	>2420
	3/4/03	>2420
	3/27/03	>2420
	4/30/03	>2420
	5/20/03	>2420
	10/8/03	>2420
DRY001.3SU	3/4/03	148
	3/27/03	>2420
	4/30/03	102
	5/20/03	52
	10/8/03	84
LAURE0007.0JO	9/11/02	38
	10/23/02	<1
	10/24/02	45
	11/25/02	49
	12/16/02	161
	1/21/03	387
	3/4/03	29
	3/26/03	385

Table B-1 (Cont.). TDEC Water Quality Monitoring Data – South Fork Holston Subwatersheds

Monitoring Station	Date	E. Coli
		[cts./100 mL]
LAURE0007.0JO (cont'd)	4/29/03	5
	5/20/03	87
	10/1/03	105
LAURE013.8JO	9/11/02	308
	10/16/02	1733
	10/24/02	613
	11/25/02	184
	12/16/02	125
	1/21/03	613
	3/4/03	980
	3/26/03	1046
	4/29/03	21
	5/20/03	435
	10/1/03	411
	9/11/02	DRY
	10/16/02	1986
	10/24/02	308
LAURE015.0JO	11/25/02	1553
	12/16/02	770
	1/21/03	>2420
	3/4/03	>2420
	3/26/03	>2420
	4/29/03	<1
	5/20/03	2420
	10/1/03	>2420
	9/19/02	225
	10/17/02	770
MORRE000.1SU	11/26/02	548
	12/3/02	679
	12/17/02	>2420
	1/22/03	2420
	3/5/03	816
	3/25/03	86
	4/30/03	179
	6/17/03	2419

Table B-1 (Cont.). TDEC Water Quality Monitoring Data – South Fork Holston Subwatersheds

Monitoring Station	Date	E. Coli
		[cts./100 mL]
PSPRI001.4SU	9/11/02	>2420
	10/24/02	1986
	11/25/02	205
	12/16/02	416
	1/21/03	>2420
	3/4/03	387
	3/27/03	921
	4/30/03	>2420
	5/20/03	167
	10/8/03	>2420
SFHOL2T0.6SU	10/17/02	613
	11/26/02	308
	12/17/02	411
	1/22/03	517
	3/5/03	179
	3/25/03	1203
	4/30/03	>2420
	6/17/03	1414
SFHOL3T0.7SU	9/19/02	>2420
	10/17/02	2420
	11/26/02	>2420
	12/3/02	>2420
	12/17/02	2420
	1/22/03	770
	3/5/03	65
	3/25/03	488
	4/30/03	1986
	6/17/03	1203
WAGNE001.9SU	9/19/02	1203
	10/17/02	770
	11/26/02	727
	12/17/02	1300

Table B-1 (Cont.). TDEC Water Quality Monitoring Data – South Fork Holston Subwatersheds

Monitoring Station	Date	E. Coli
		[cts./100 mL]
WAGNE001.9SU (cont'd)	1/22/03	219
	3/5/03	687
	3/25/03	2420
	5/1/03	>2420
	6/17/03	>2420
WATER000.1JO	10/16/02	727
	10/24/02	308
	11/25/02	345
	12/16/02	2420
	1/21/03	>2420
	3/4/03	2420
	3/26/03	291
	4/29/03	687
	5/20/03	2420
	10/1/03	66
WEAVE000.7SU	9/19/02	>2420
	10/17/02	1733
	11/26/02	548
	12/17/02	387
	1/22/03	548
	3/5/03	649
	3/25/03	167
	4/30/03	548
	6/17/03	687
WOODS000.5SU	9/19/02	770
	10/17/02	649
	11/26/02	1300
	12/17/02	1046
	1/22/03	47
	3/5/03	411
	3/25/03	770
	4/30/03	1203
	6/17/03	1986

APPENDIX C

Development of TMDLs, WLAs, & LAs

The TMDL process quantifies the amount of a pollutant that can be assimilated in a waterbody, identifies the sources of the pollutant, and recommends regulatory or other actions to be taken to achieve compliance with applicable water quality standards based on the relationship between pollution sources and in-stream water quality conditions. A TMDL can be expressed as the sum of all point source loads (Waste Load Allocations), nonpoint source loads (Load Allocations), and an appropriate margin of safety (MOS) that takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

$$\text{TMDL} = \Sigma \text{WLAs} + \Sigma \text{LAs} + \text{MOS}$$

The objective of a TMDL is to allocate loads among all of the known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. 40 CFR §130.2 (i) states that TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measure.

C.1 Development of TMDLs

E. coli TMDLs, WLAs, and LAs were developed for impaired subwatersheds and drainage areas in the South Fork Holston River Watershed using Load Duration Curves (LDCs) to determine the reduction in pollutant loading required to decrease existing, instream E. coli concentrations to target levels. TMDLs are expressed as required percent reductions in pollutant loading.

C.1.1 Development of Flow Duration Curves

A flow duration curve is a cumulative frequency graph, constructed from historic flow data at a particular location, that represents the percentage of time a particular flow rate is equaled or exceeded. Flow duration curves are developed for a waterbody from daily discharges of flow over a period of record. In general, there is a higher level of confidence that curves derived from data over a long period of record correctly represent the entire range of flow. The preferred method of flow duration curve computation uses daily mean data from USGS continuous-record stations located on the waterbody of interest. For ungaged streams, alternative methods must be used to estimate daily mean flow. These include: 1) regression equations (using drainage area as the independent variable) developed from continuous record stations in the same ecoregion; 2) drainage area extrapolation of data from a nearby continuous-record station of similar size and topography; and 3) calculation of daily mean flow using a dynamic computer model, such as the Loading Simulation Program C++ (LSPC).

Flow duration curves for impaired waterbodies in the South Fork Holston River Watershed were derived from LSPC hydrologic simulations based on parameters derived from calibrations at USGS Station No. 03479000, located on Watauga River near Sugar Grove, North Carolina, in the Watauga River watershed and USGS Station No. 03535000, located on Bullrun Creek near Halls Crossroads, Tennessee, in the Lower Clinch watershed (see Appendix D for details of calibration). For example, a flow-duration curve for Back Creek at RM 0.5 was constructed using simulated daily mean flow for the period from 10/1/94 through 9/31/04 (RM 0.5 corresponds to the location of monitoring station BACK000.5SU). This flow duration curve is shown in Figure C-1 and represents the cumulative distribution of daily discharges arranged to show percentage of time specific flows were exceeded during the period of record (the highest daily mean flow during this period is exceeded 0% of the time and the lowest daily mean flow is equaled or exceeded 100% of the time).

Flow duration curves for other impaired waterbodies were derived using a similar procedure.

C.1.2 Development of Load Duration Curves and Determination of TMDLs

When a water quality target concentration is applied to the flow duration curve, the resulting load duration curve (LDC) represents the allowable pollutant loading in a waterbody over the entire range of flow. Pollutant monitoring data, plotted on the LDC, provides a visual depiction of stream water quality as well as the frequency and magnitude of any exceedances. Load duration curve intervals can be grouped into several broad categories or zones, in order to provide additional insight about conditions and patterns associated with the impairment. For example, the duration curve could be divided into five zones: high flows (exceeded 0-10% of the time), moist conditions (10-40%), median or mid-range flows (40-60%), dry conditions (60-90%), and low flows (90-100%).

Impairments observed in the low flow zone typically indicate the influence of point sources, while those further left on the LDC (representing zones of higher flow) generally reflect potential nonpoint source contributions (Stiles, 2003).

E. coli load duration curves for impaired waterbodies in the South Fork Holston River Watershed were developed from the flow duration curves developed in Section C.1.1, E. coli target concentrations, and available water quality monitoring data. Load duration curves and required load reductions were developed using the following procedure (Back Creek is shown as an example):

1. A target load-duration curve (LDC) was generated for Back Creek by applying the E. coli target concentration of 941 CFU/100 mL to each of the ranked flows used to generate the flow duration curve (ref.: Section D.1) and plotting the results. The E. coli target maximum load corresponding to each ranked daily mean flow is:

$$(\text{Target Load})_{\text{Back Creek}} = (941 \text{ CFU/100 mL}) \times (Q) \times (\text{UCF})$$

where: Q = daily mean flow

UCF = the required unit conversion factor

2. Daily loads were calculated for each of the water quality samples collected at monitoring station BACK000.5SU (ref.: Table B-1) by multiplying the sample concentration by the daily mean flow for the sampling date and the required unit conversion factor. BACK000.5SU was selected for LDC analysis because it was the monitoring station on Back Creek with the most exceedances of the target concentration.

Note: In order to be consistent for all analyses, the derived daily mean flow was used to compute sampling data loads, even if measured ("instantaneous") flow data was available for some sampling dates.

Example – 8/20/02 sampling event:

Modelled Flow = 1.11 cfs

Concentration = 1300 CFU/100 mL

Daily Load = 3.53×10^{10} CFU/day

3. Using the flow duration curves developed in C.1.1, the "percent of days the flow was exceeded" (PDFE) was determined for each sampling event. Each sample load was then plotted on the load duration curves developed in Step 1 according to the PDFE. The resulting E. coli load duration curve for is shown in Figure C-15.

4. For cases where the existing load exceeded the target maximum load at a particular PDPE, the reduction required to reduce the sample load to the target load was calculated.

Example – 8/20/02 sampling event:

Target Concentration = 941 CFU/100 mL

Measured Concentration = 1300 CFU/100 mL

Reduction to Target = 27.6%

5. The 90th percentile value for all of the E. coli sampling data at BACK000.5SU monitoring site was determined. If the 90th percentile value exceeded the target maximum E. coli concentration, the reduction required to reduce the 90th percentile value to the target maximum concentration was calculated (Table C-14).

Example:

Target Concentration = 941 CFU/100 mL

90th Percentile Concentration = 1697 CFU/100 mL

Reduction to Target = 44.6%

6. For cases where five or more samples were collected over a period of not more than 30 consecutive days, the geometric mean E. coli concentration was determined and compared to the target geometric mean E. coli concentration of 126 CFU/100 mL. If the sample geometric mean exceeded the target geometric mean concentration, the reduction required to reduce the sample geometric mean value to the target geometric mean concentration was calculated.

Example:

Insufficient monitoring data was available for any monitoring station in the South Fork Holston River watershed

7. The load reductions required to meet the target maximum (Step 5) and target 30-day geometric mean concentrations (Step 6) of E. coli were compared and the load reduction of the greatest magnitude selected as the TMDL for Back Creek.

Load duration curves, required load reductions, and TMDLs of other impaired waterbodies were derived in a similar manner and are shown in Figures C-2 through C-24 and Tables C-1 through C-17.

C.2 Development of WLAs & LAs

As previously discussed, a TMDL can be expressed as the sum of all point source loads (WLAs), nonpoint source loads (LAs), and an appropriate margin of safety (MOS) that takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

$$\text{TMDL} = \Sigma \text{WLAs} + \Sigma \text{LAs} + \text{MOS}$$

Expanding the terms:

$$\text{TMDL} = [\Sigma \text{WLAs}]_{\text{WWTF}} + [\Sigma \text{WLAs}]_{\text{MS4}} + [\Sigma \text{WLAs}]_{\text{CAFO}} + [\Sigma \text{LAs}]_{\text{DS}} + [\Sigma \text{LAs}]_{\text{SW}} + \text{MOS}$$

For pathogen TMDLs in each impaired subwatershed or drainage area, WLA terms include:

- $[\Sigma WLA]_{WWTF}$ is the allowable load associated with discharges of NPDES permitted WWTFs located in impaired subwatersheds or drainage areas. Since NPDES permits for these facilities specify that treated wastewater must meet instream water quality standards at the point of discharge, no additional load reduction is required. WLAs for WWTFs are calculated from the facility design flow and the Monthly Average permit limit.
- $[\Sigma WLA]_{CAFO}$ is the allowable load for all CAFOs in an impaired subwatershed or drainage area. All wastewater discharges from a CAFO to waters of the state of Tennessee are prohibited, except when either chronic or catastrophic rainfall events cause an overflow of process wastewater from a facility properly designed, constructed, maintained, and operated to contain:
 - All process wastewater resulting from the operation of the CAFO (such as wash water, parlor water, watering system overflow, etc.); plus,
 - All runoff from a 25-year, 24-hour rainfall event for the existing CAFO or new dairy or cattle CAFOs; or all runoff from a 100-year, 24-hour rainfall event for a new swine or poultry CAFO.

Therefore, a WLA of zero has been assigned to this class of facilities.

- $[\Sigma WLA]_{MS4}$ is the required load reduction for discharges from MS4s. E. coli loading from MS4s is the result of buildup/wash-off processes associated with storm events.

LA terms include:

- $[\Sigma LA]_{DS}$ is the allowable E. coli load from “other direct sources”. These sources include leaking septic systems, illicit discharges, and animals access to streams. The LA specified for all sources of this type is zero CFU/day (or to the maximum extent practicable).
- $[\Sigma LA]_{SW}$ represents the required reduction in E. coli loading from nonpoint sources indirectly going to surface waters from all land use areas (except areas covered by a MS4 permit) as a result of the buildup/wash-off processes associated with storm events.

Since WWTFs discharges must comply with instream water quality criteria (TMDL target) at the point of discharge, $[\Sigma WLA]_{CAFO} = 0$, and $[\Sigma LA]_{DS} = 0$, the expression relating TMDLs to precipitation-based point and nonpoint sources may be simplified to:

$$TMDL - MOS = [\Sigma WLA]_{MS4} + [\Sigma LA]_{SW}$$

WLAs for MS4s and LAs for precipitation-based nonpoint sources are equal and expressed as the percent reduction in loading required to decrease instream E. coli concentrations to TMDL target values minus MOS. As stated in Section 8.4, an explicit MOS, equal to 10% of the E. coli water quality targets (ref.: Section 5.0), was utilized for determination of the WLAs and LAs:

Instantaneous Maximum: Target – MOS = (941 CFU/100 ml) – 0.1(941 CFU/100 ml)
 Target – MOS = 847 CFU/100 ml

30-Day Geometric Mean: Target – MOS = (126 CFU/100 ml) – 0.1(126 CFU/100 ml)
 Target – MOS = 113 CFU/100 ml

C.2.1 Determination of WLAs for MS4s & LAs for Precipitation-Based Nonpoint Sources

WLAs for MS4s and LAs for precipitation-based nonpoint sources were developed using methods similar to those described in C.1.2 (again, using Back Creek as an example):

8. An allocation LDC was generated for Back Creek by applying the E. coli “target – MOS” concentration of 847 CFU/100 mL to each of the ranked flows used to generate the flow duration curve (ref.: Section D.1) and plotting the results on the target LDC developed in Step 1. The E. coli target maximum allocated load corresponding to each ranked daily mean flow is:

$$(\text{Target Load} - \text{MOS})_{\text{Back Creek}} = (847 \text{ CFU/100 mL}) \times (Q) \times (\text{UCF})$$

where: Q = daily mean flow

UCF = the required unit conversion factor

9. For cases where the existing load exceeded the “target maximum load – MOS” at a particular PDPE, the reduction required to reduce the sample load to the “target – MOS” load was calculated.

Example – 8/20/02 sampling event:

Target Concentration – MOS = 847 CFU/100 mL

Measured Concentration = 1300 CFU/100 mL

Reduction to Target – MOS = 34.8%

10. If the 90th percentile value for all of the E. coli sampling data at BACK000.5SU monitoring site (calculated in Step 5) exceeded the “target maximum – MOS” E. coli concentration, the reduction required to reduce the 90th percentile value to the “target maximum – MOS” concentration was calculated (Table C-14).

Example:

Target Concentration – MOS = 847 CFU/100 mL

90th Percentile Concentration = 1697 CFU/100 mL

Reduction to Target – MOS = 50.1%

11. For cases where five or more samples were collected over a period of not more than 30 consecutive days, the geometric mean E. coli concentration was determined and compared to the “target geometric mean E. coli concentration – MOS” of 113 CFU/100 mL. If the sample geometric mean exceeded the “target geometric mean – MOS” concentration, the reduction required to reduce the sample geometric mean value to the “target geometric mean – MOS” concentration was calculated.

Example: Insufficient monitoring data was available for any monitoring station in the South Fork Holston River watershed

12. The load reductions required to meet the “target maximum – MOS” (Step 10) and “target 30-day geometric mean – MOS” concentrations (Step 11) of E. coli were compared and the load reduction of the greatest magnitude selected as the WLA for MS4s and/or LA for precipitation-based nonpoint sources for Back Creek.

Load duration curves, required load reductions, WLAs for MS4s, and LAs for precipitation-based nonpoint sources of other impaired waterbodies were derived in a similar manner and are shown in Figures C-2 through C-18 and Tables C-1 through C-17. TMDLs, WLAs, & LAs for impaired subwatersheds and drainage areas in the South Fork Holston River Watershed are summarized in Table C-18.

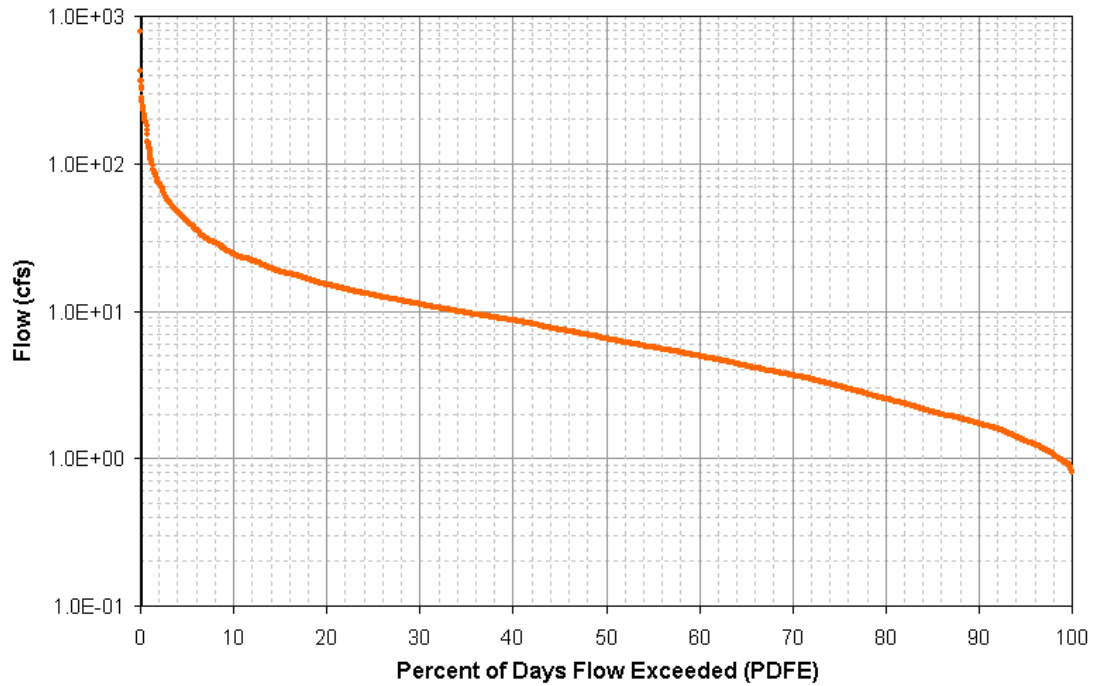


Figure C-1 Flow Duration Curve for Back Creek at BACK000.5SU

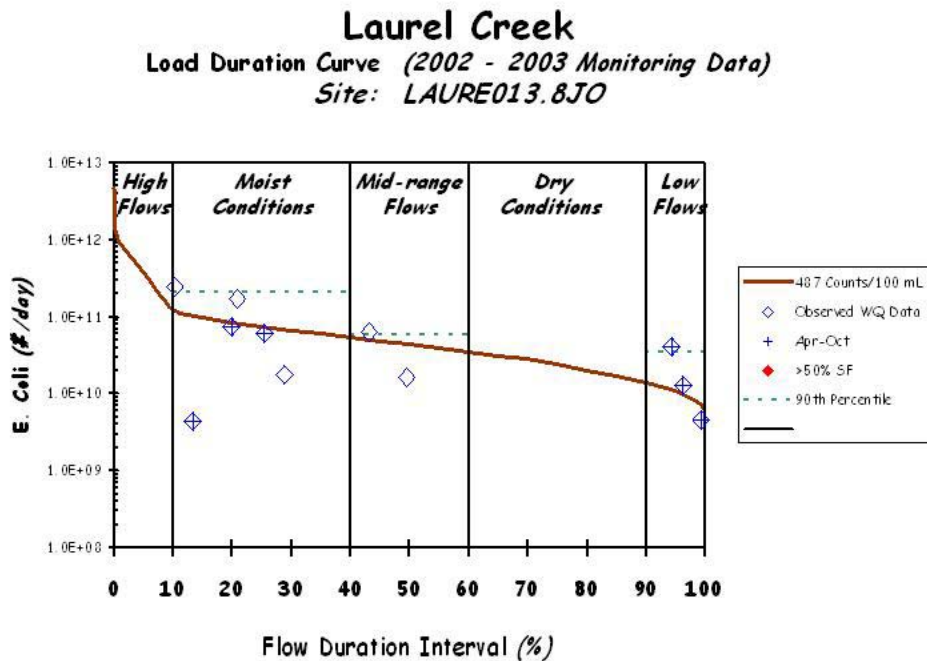


Figure C-2 E. Coli Load Duration Curve for Laurel Creek at LAURE013.8JO

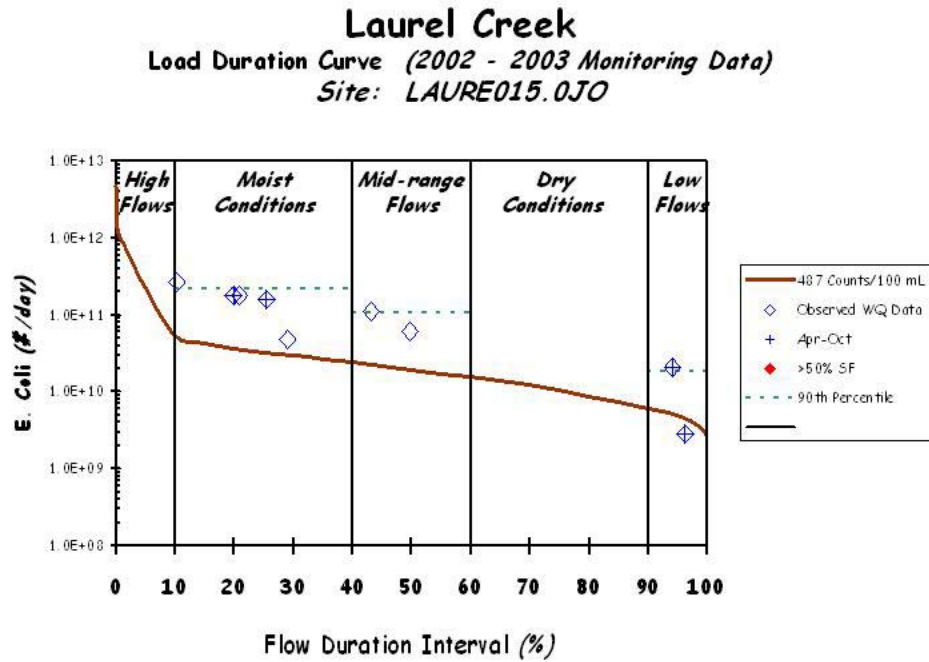


Figure C-3 E. Coli Load Duration Curve for Laurel Creek at LAURE015.0JO

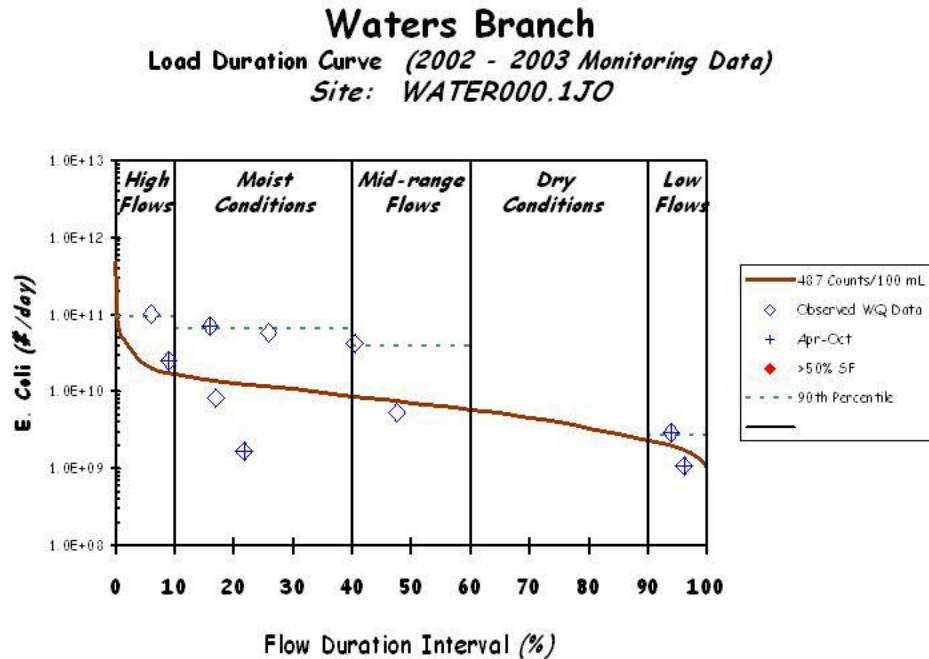


Figure C-4 E. Coli Load Duration Curve for Waters Branch

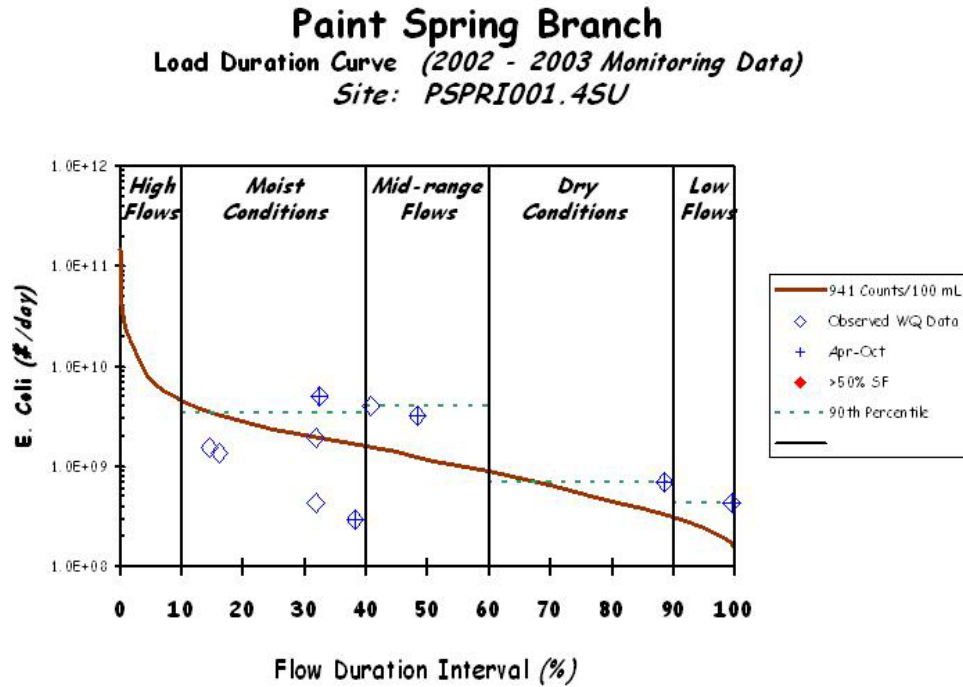


Figure C-5 E. Coli Load Duration Curve for Paint Spring Branch

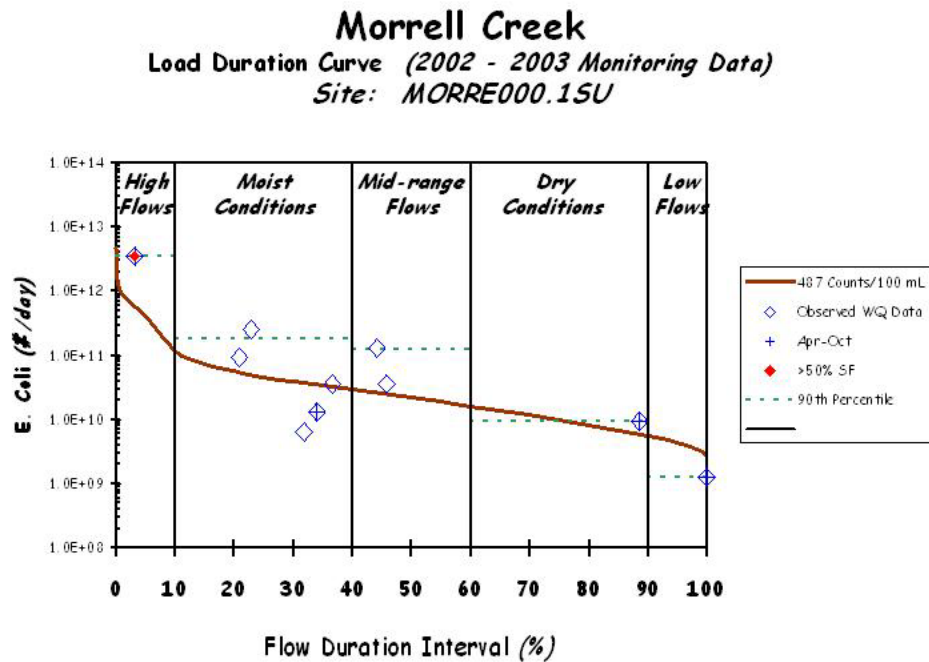


Figure C-6 E. Coli Load Duration Curve for Morrell Creek

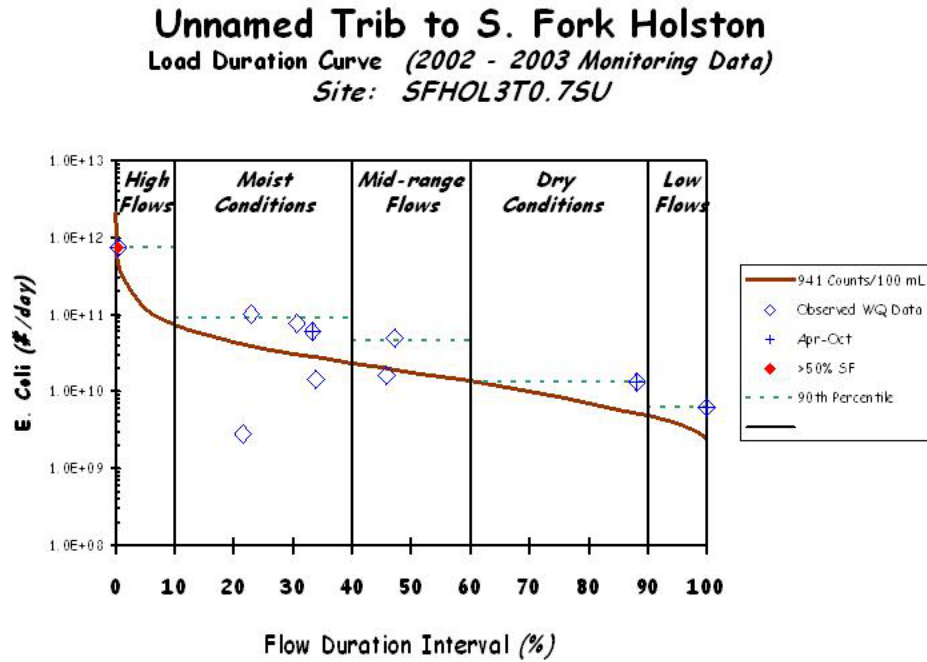


Figure C-7 E. Coli Load Duration Curve for Unnamed Trib to S. Fork Holston (SFHOL3T0.7SU)

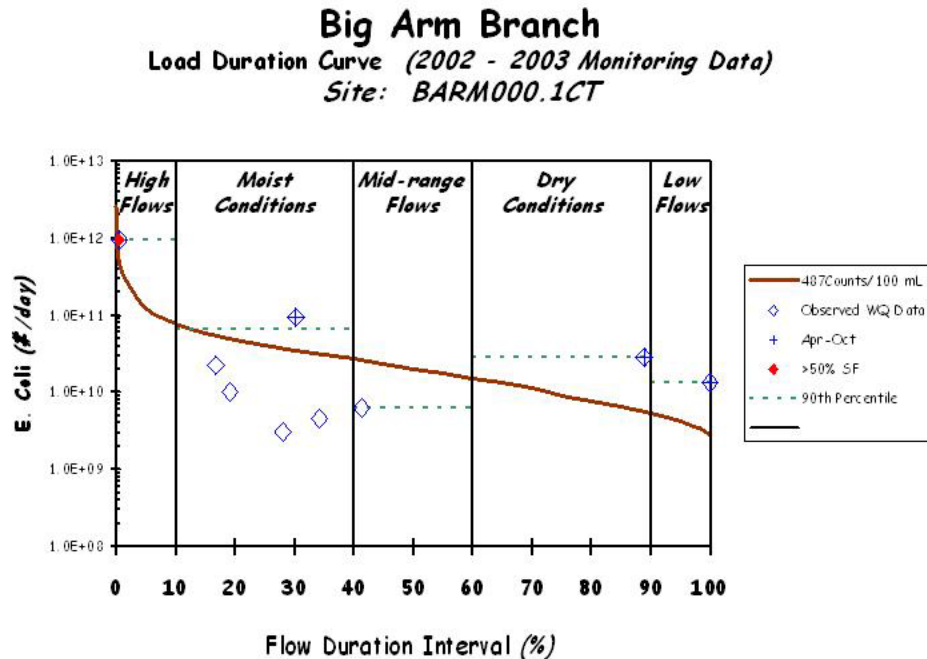


Figure C-8 E. Coli Load Duration Curve for Big Arm Branch

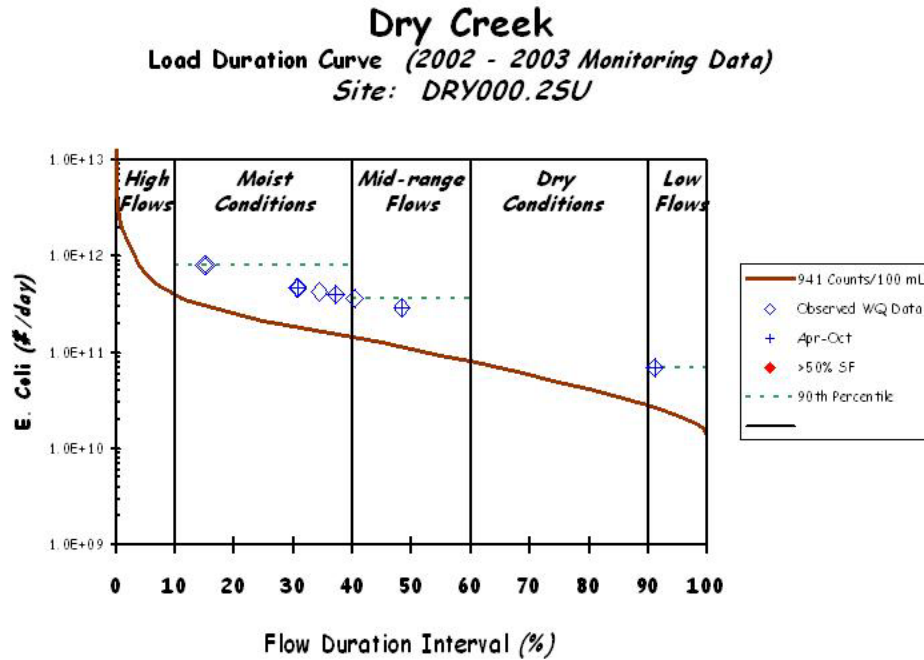


Figure C-9 E. Coli Load Duration Curve for Dry Creek at DRY000.2SU

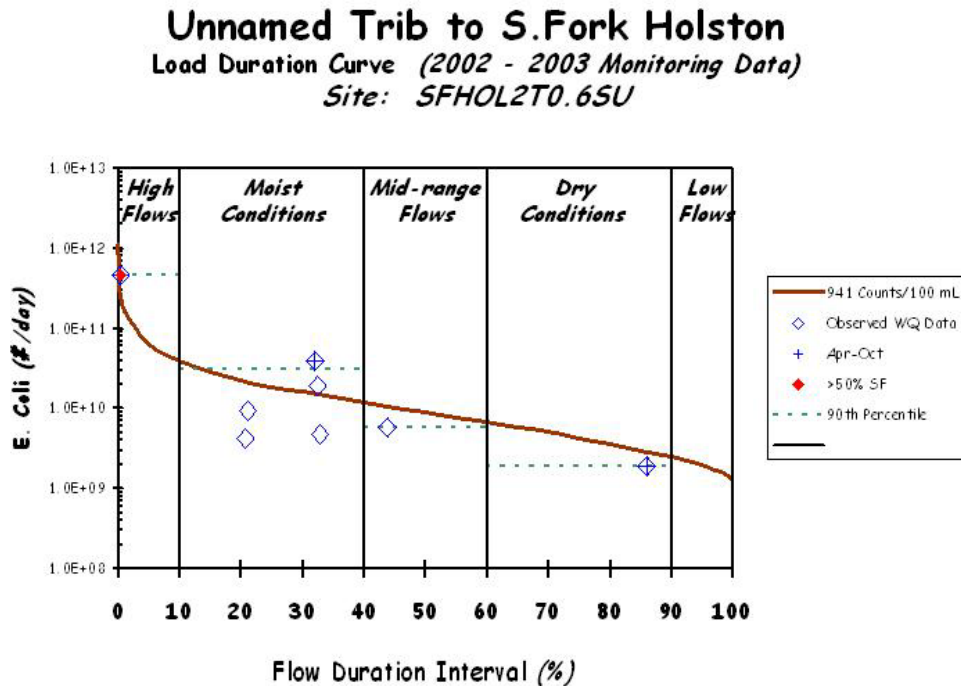


Figure C-10 E. Coli Load Duration Curve for Unnamed Trib to S. Fork Holston (SFHOL2T0.6SU)

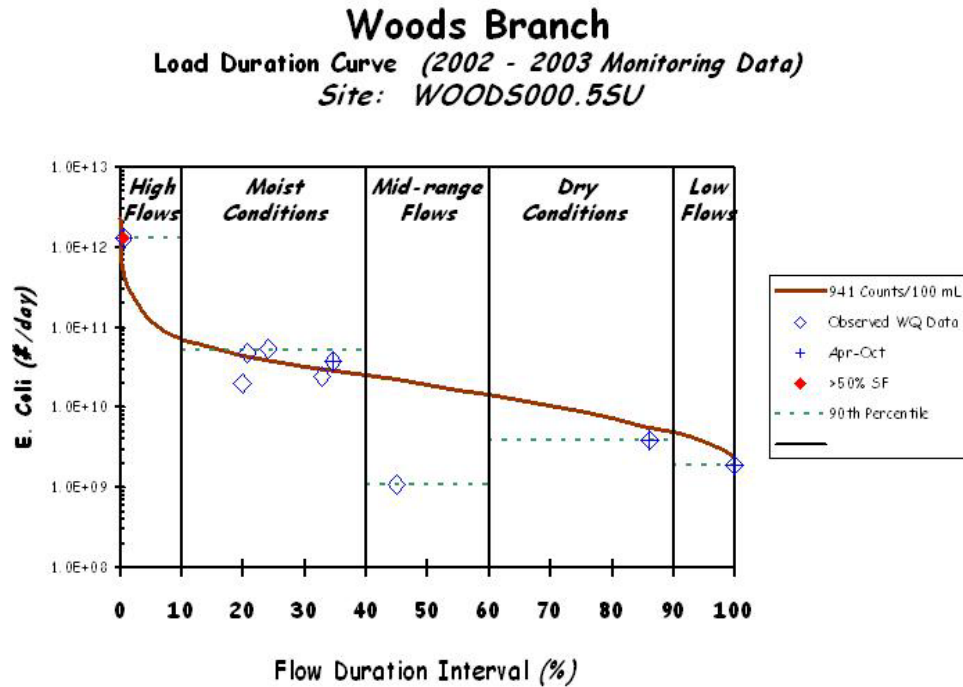


Figure C-11 E. Coli Load Duration Curve for Woods Branch

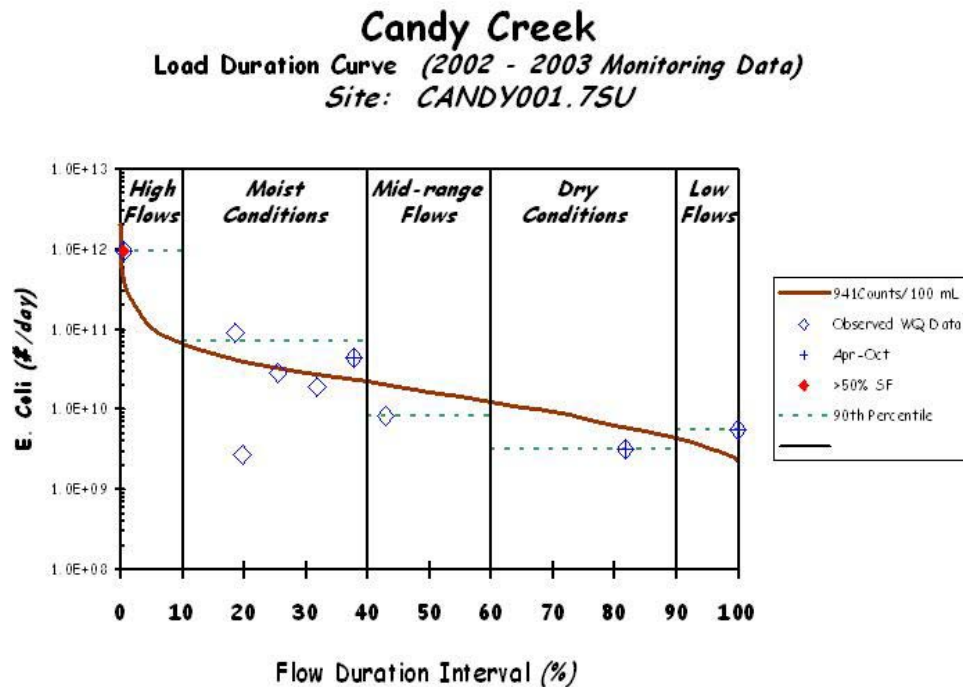


Figure C-12 E. Coli Load Duration Curve for Candy Creek

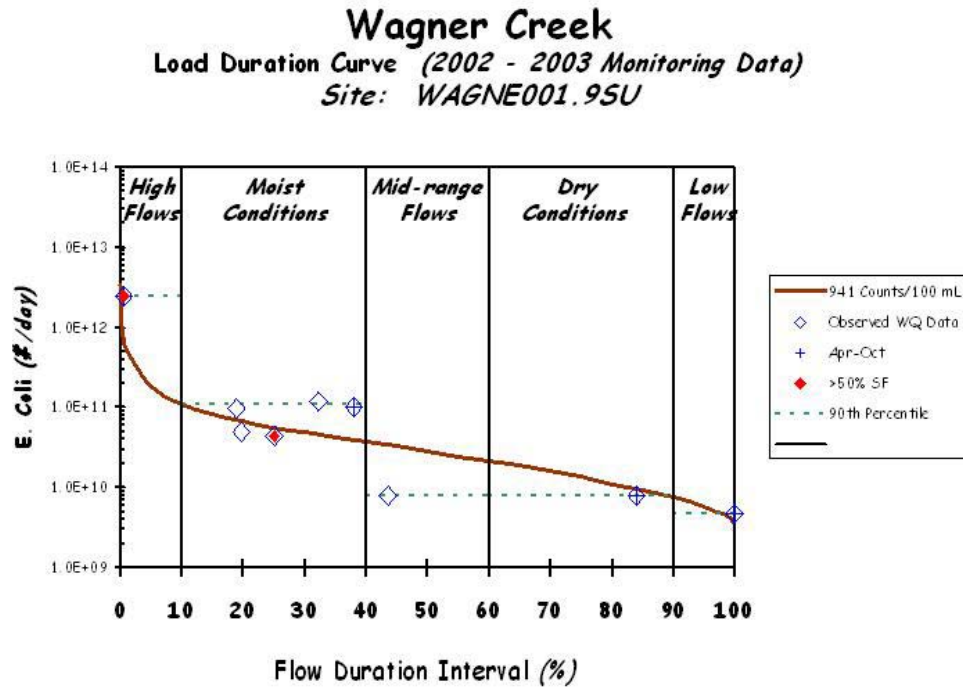


Figure C-13 E. Coli Load Duration Curve for Wagner Creek

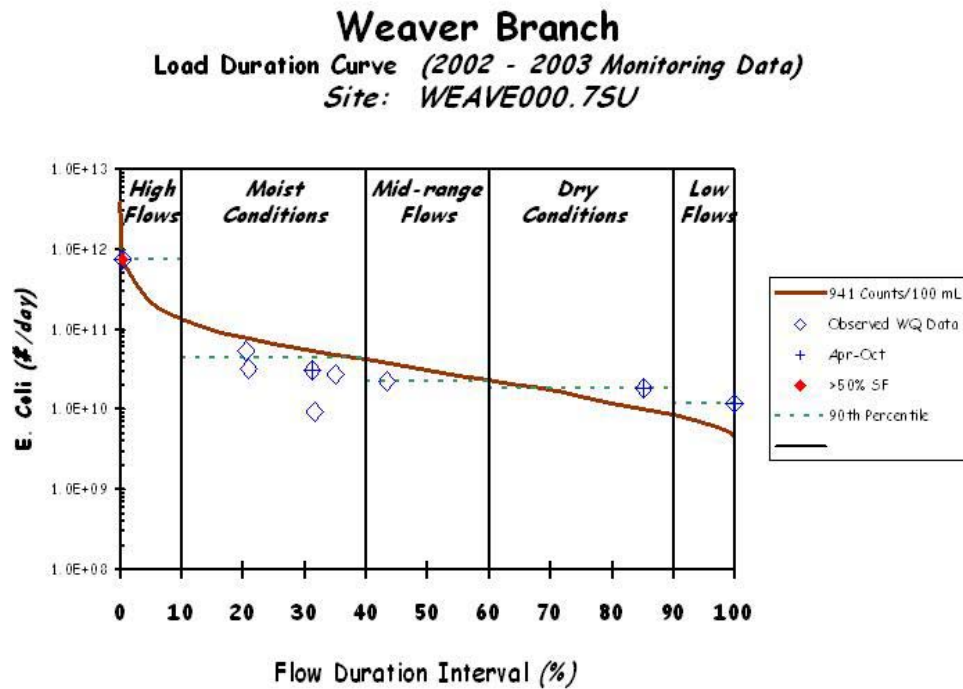


Figure C-14 E. Coli Load Duration Curve for Weaver Branch

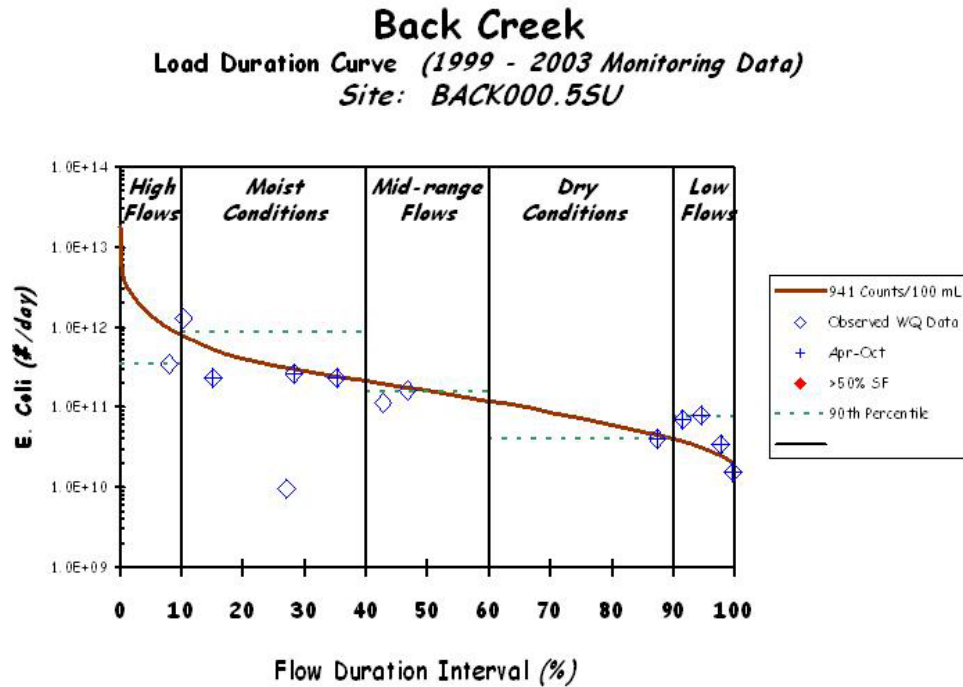


Figure C-15 E. Coli Load Duration Curve for Back Creek at BACK000.5SU

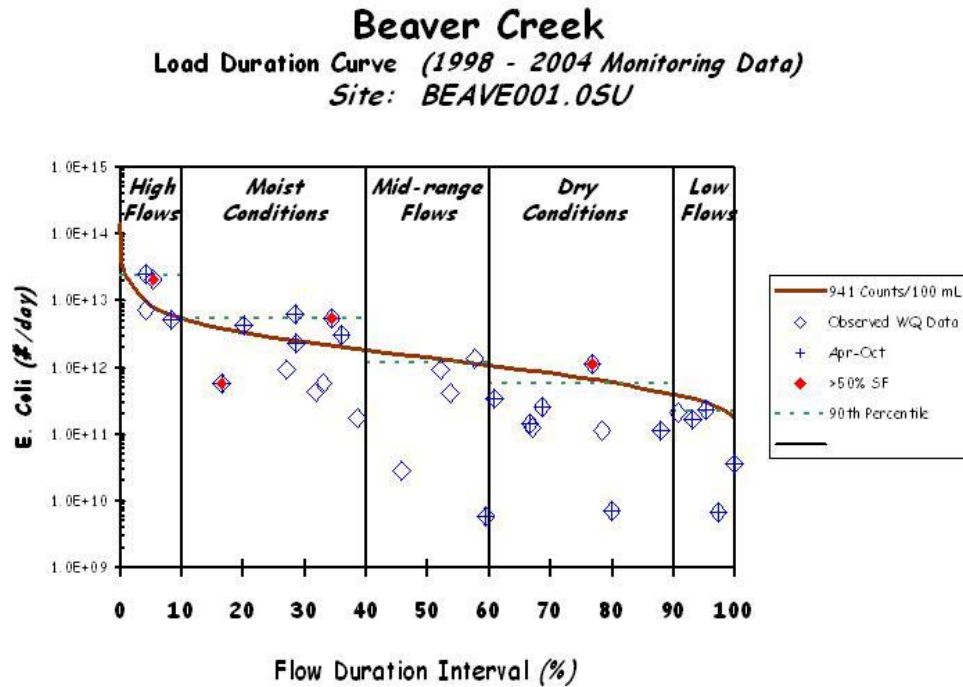


Figure C-16 E. Coli Load Duration Curve for Beaver Creek at BEAVE001.0SU

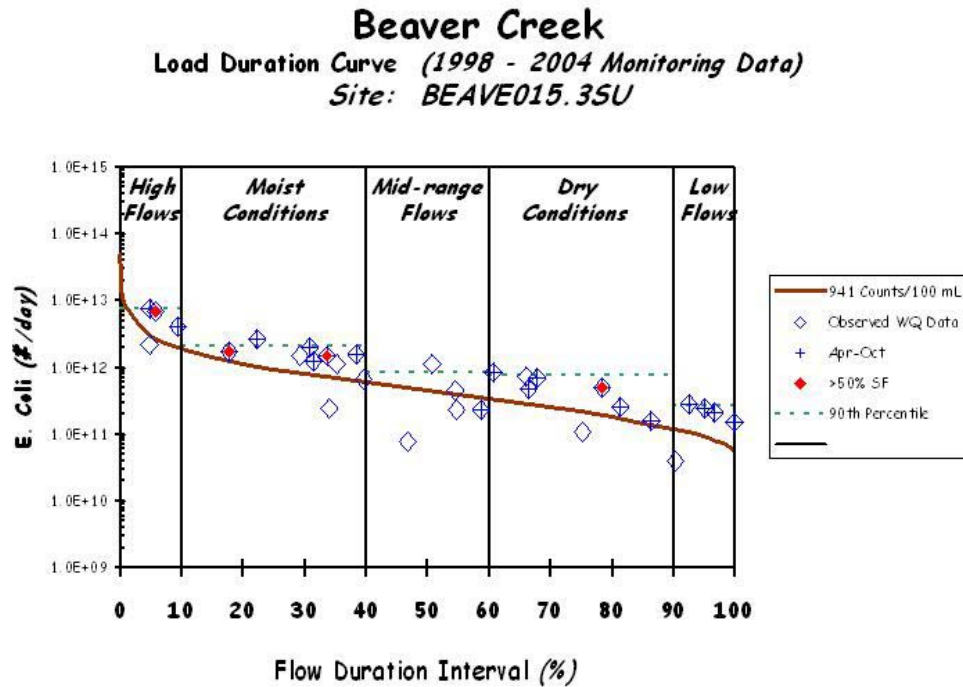


Figure C-17 E. Coli Load Duration Curve for Beaver Creek at BEAVE015.3SU

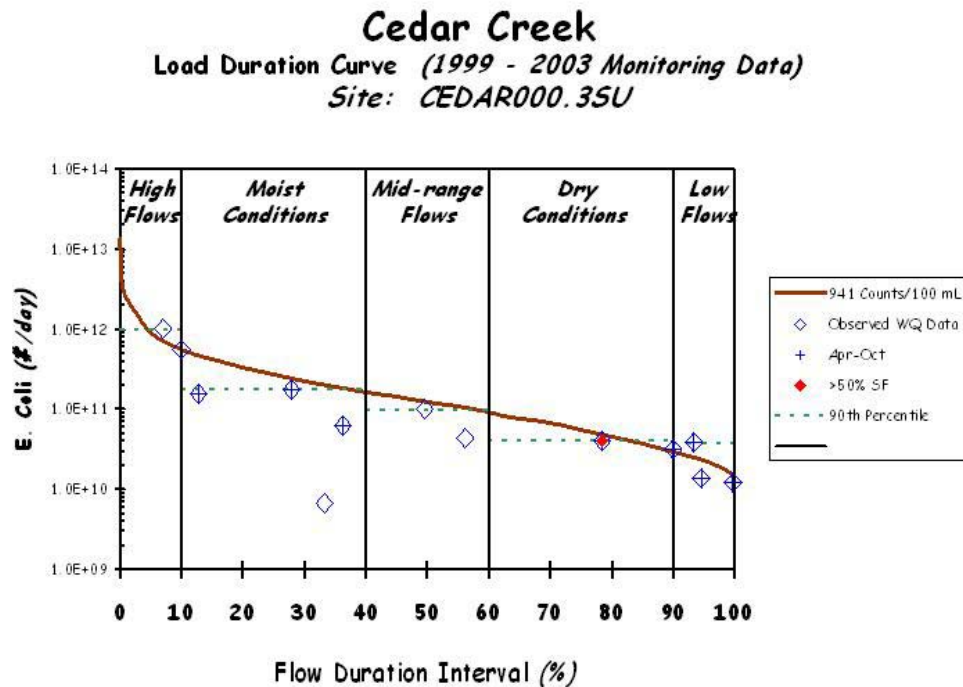


Figure C-18 E. Coli Load Duration Curve for Cedar Creek

Table C-1 Required Load Reduction for Laurel Creek at LAURE013.8JO

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (487 CFU/100 ml)	Sample to Target - MOS (438 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
9/11/02	0.61	99.4	308	NR	NR
10/16/02	0.96	94.4	1733	71.9	74.7
10/24/02	0.85	96.5	613	20.6	28.6
11/25/02	3.68	49.7	184	NR	NR
12/16/02	5.77	28.8	125	NR	NR
1/21/03	4.26	43.2	613	20.6	28.6
3/4/03	10.12	10.3	980	50.3	55.3
3/26/03	6.80	20.9	1046	53.4	58.1
4/29/03	8.56	13.4	21	NR	NR
5/20/03	6.94	19.9	435	NR	NR
10/1/03	6.17	25.5	411	NR	NR
90th Percentile Concentration			1046	53.4	58.1

- Notes: 1. NR = No reduction required.
2. 30-day Geometric Mean could not be calculated due to insufficient data.
3. Reductions for individual samples (shaded area) is included for reference only.

Table C-2 Required Load Reduction for Laurel Creek at LAURE015.0JO

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (487 CFU/100 ml)	Sample to Target - MOS (438 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
10/16/02	0.42	94.3	1986	75.5	78.0
10/24/02	0.37	96.5	308	NR	NR
11/25/02	1.61	49.9	1553	68.6	71.8
12/16/02	2.53	29.1	770	36.8	43.1
1/21/03	1.87	43.2	>2420	>79.9	>81.9
3/4/03	4.45	10.3	>2420	>79.9	>81.9
3/26/03	2.99	20.9	>2420	>79.9	>81.9
4/29/03	3.77	13.3	<1	NR	NR
5/20/03	3.05	20.0	2420	79.9	81.9
10/1/03	2.71	25.5	>2420	>79.9	>81.9
90th Percentile Concentration			>2420	>79.9	>81.9

- Notes: 1. NR = No reduction required.
2. 30-day Geometric Mean could not be calculated due to insufficient data.
3. Reductions for individual samples (shaded area) is included for reference only.

Table C-3 Required Load Reduction for Waters Branch

Sample Date	Flow	PDPE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (487 CFU/100 ml)	Sample to Target - MOS (438 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
10/16/02	0.17	94.0	727	33.0	39.8
10/24/02	0.15	96.3	308	NR	NR
11/25/02	0.63	47.6	345	NR	NR
12/16/02	0.99	25.8	2420	79.9	81.9
1/21/03	0.73	40.4	>2420	>79.9	>81.9
3/4/03	1.75	5.9	2420	79.9	81.9
3/26/03	1.18	17.0	291	NR	NR
4/29/03	1.48	8.9	687	29.1	36.2
5/20/03	1.20	15.9	2420	79.9	81.9
10/1/03	1.06	21.8	66	NR	NR
90th Percentile Concentration			>2420	>79.9	>81.9

- Notes:
1. NR = No reduction required.
 2. 30-day Geometric Mean could not be calculated due to insufficient data.
 3. Reductions for individual samples (shaded area) is included for reference only.

Table C-4 Required Load Reduction for Paint Spring Branch

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (941 CFU/100 ml)	Sample to Target - MOS (847 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
9/11/02	0.01	99.7	>2420	>61.1	>65.0
10/24/02	0.01	88.7	1986	52.6	57.4
11/25/02	0.09	31.8	205	NR	NR
12/16/02	0.15	14.5	416	NR	NR
1/21/03	0.07	40.8	>2420	>61.1	>65.0
3/4/03	0.15	16.1	387	NR	NR
3/27/03	0.09	31.8	921	NR	8.0
4/30/03	0.08	32.4	>2420	>61.1	>65.0
5/20/03	0.07	38.3	167	NR	NR
10/8/03	0.05	48.4	>2420	>61.1	>65.0
90th Percentile Concentration			>2420	>61.1	>65.0

- Notes: 1. NR = No reduction required.
2. 30-day Geometric Mean could not be calculated due to insufficient data.
3. Reductions for individual samples (shaded area) is included for reference only.

Table C-5 Required Load Reduction for Morrell Creek

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (487 CFU/100 ml)	Sample to Target - MOS (438 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
9/19/02	0.23	100.0	225	NR	NR
10/17/02	0.49	88.7	770	36.8	43.1
11/26/02	2.72	36.7	548	11.1	20.1
12/3/02	2.11	45.9	679	28.3	35.5
12/17/02	4.22	23.0	>2420	>79.9	>81.9
1/22/03	2.22	44.2	2420	79.9	81.9
3/5/03	4.57	21.0	816	40.3	46.3
3/25/03	3.11	31.9	86	NR	NR
4/30/03	2.94	34.0	179	NR	NR
6/17/03	59.68	3.1	2419	79.9	81.9
90th Percentile Concentration			>2420	>79.9	>81.9

- Notes: 1. NR = No reduction required.
 2. 30-day Geometric Mean could not be calculated due to insufficient data.
 3. Reductions for individual samples (shaded area) is included for reference only.

**Table C-6 Required Load Reduction for Unnamed Trib to S. Fork Holston
 (SFHOL3T0.7SU)**

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (941 CFU/100 ml)	Sample to Target - MOS (847 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
9/19/02	0.11	100.0	>2420	>61.1	>65.0
10/17/02	0.23	88.2	>2420	>61.1	>65.0
11/26/02	1.33	30.7	>2420	>61.1	>65.0
12/3/02	0.83	47.3	>2420	>61.1	>65.0
12/17/02	1.72	23.0	2420	61.1	65.0
1/22/03	0.87	45.8	770	NR	NR
3/5/03	1.81	21.6	65	NR	NR
3/25/03	1.22	33.8	488	NR	NR
4/30/03	1.24	33.3	1986	52.6	57.4
6/17/03	25.05	0.4	1203	59.5	63.6
90th Percentile Concentration			>2420	>61.1	>65.0

- Notes: 1. NR = No reduction required.
 2. 30-day Geometric Mean could not be calculated due to insufficient data.
 3. Reductions for individual samples (shaded area) is included for reference only.

Table C-7 Required Load Reduction for Big Arm Branch

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (487 CFU/100 ml)	Sample to Target - MOS (438 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
9/19/02	0.23	100.0	>2420	>79.9	>81.9
10/17/02	0.47	88.9	>2420	>79.9	>81.9
11/26/02	2.64	34.3	71	NR	NR
12/17/02	4.13	19.3	99	NR	NR
1/22/03	2.20	41.4	118	NR	NR
3/5/03	4.56	16.9	201	NR	NR
3/25/03	3.10	28.1	40	NR	NR
4/30/03	2.94	30.2	1300	62.5	66.3
6/17/03	59.43	0.5	649	25.0	32.5
90th Percentile Concentration			>2420	>79.9	>81.9

Notes: 1. NR = No reduction required.
2. 30-day Geometric Mean could not be calculated due to insufficient data.
3. Reductions for individual samples (shaded area) is included for reference only.

Table C-8 Required Load Reduction for Dry Creek at DRY000.2SU

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (941U/100 ml)	Sample to Target - MOS (847U/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
10/24/02	1.19	91.2	>2420	>61.1	>65.0
11/25/02	7.21	34.5	>2420	>61.1	>65.0
12/16/02	13.62	14.9	>2420	>61.1	>65.0
1/21/03	6.20	40.4	>2420	>61.1	>65.0
3/4/03	13.42	15.3	>2420	>61.1	>65.0
3/27/03	7.98	30.7	>2420	>61.1	>65.0
4/30/03	7.90	30.9	>2420	>61.1	>65.0
5/20/03	6.78	37.2	>2420	>61.1	>65.0
10/8/03	4.86	48.5	>2420	>61.1	>65.0
90th Percentile Concentration			>2420	>61.1	>65.0

- Notes:
1. NR = No reduction required.
 2. 30-day Geometric Mean could not be calculated due to insufficient data.
 3. Reductions for individual samples (shaded area) is included for reference only.

**Table C-9 Required Load Reduction for Unnamed Trib to S. Fork Holston
 (SFHOL2T0.6SU)**

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (941 CFU/100 ml)	Sample to Target - MOS (847 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
10/17/02	0.13	86.0	613	NR	NR
11/26/02	0.64	32.8	308	NR	NR
12/17/02	0.94	21.2	411	NR	NR
1/22/03	0.47	43.8	517	NR	NR
3/5/03	0.95	20.8	179	NR	NR
3/25/03	0.65	32.4	1203	21.8	29.6
4/30/03	0.65	32.1	>2420	>61.1	>65.0
6/17/03	13.24	0.4	1414	33.5	40.1
90th Percentile Concentration			>1716	>45.2	>50.6

- Notes: 1. NR = No reduction required.
 2. 30-day Geometric Mean could not be calculated due to insufficient data.
 3. Reductions for individual samples (shaded area) is included for reference only.

Table C-10 Required Load Reduction for Woods Branch

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (941 CFU/100 ml)	Sample to Target - MOS (847 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
9/19/02	0.10	100.0	770	NR	NR
10/17/02	0.25	86.3	649	NR	NR
11/26/02	1.70	24.1	1300	27.6	34.9
12/17/02	1.89	20.7	1046	10.0	19.0
1/22/03	0.96	45.1	47	NR	NR
3/5/03	1.96	20.0	411	NR	NR
3/25/03	1.31	32.9	770	NR	NR
4/30/03	1.26	34.6	1203	21.8	29.6
6/17/03	26.98	0.5	1986	52.6	57.4
90th Percentile Concentration			1437	34.5	41.1

- Notes:
1. NR = No reduction required.
 2. 30-day Geometric Mean could not be calculated due to insufficient data.
 3. Reductions for individual samples (shaded area) is included for reference only.

Table C-11 Required Load Reduction for Candy Creek

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (941 CFU/100 ml)	Sample to Target - MOS (847 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
9/19/02	0.10	100.0	>2420	>61.1	>65.0
10/17/02	0.26	81.8	517	NR	NR
11/26/02	1.44	25.5	816	NR	NR
12/17/02	1.84	18.6	1986	52.6	57.4
1/22/03	0.90	42.9	387	NR	NR
3/5/03	1.77	19.8	64	NR	NR
3/25/03	1.20	31.8	649	NR	NR
5/1/03	1.03	37.8	1733	45.7	51.1
6/17/03	25.06	0.5	1553	39.4	45.5
90th Percentile Concentration			>2073	>54.6	>59.1

- Notes:
1. NR = No reduction required.
 2. 30-day Geometric Mean could not be calculated due to insufficient data.
 3. Reductions for individual samples (shaded area) is included for reference only.

Table C-12 Required Load Reduction for Wagner Creek

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (941 CFU/100 ml)	Sample to Target - MOS (847 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
9/19/02	0.16	100.0	1203	21.8	29.6
10/17/02	0.42	84.1	770	NR	NR
11/26/02	2.47	25.1	727	NR	NR
12/17/02	3.04	19.0	1300	27.6	34.8
1/22/03	1.49	43.7	219	NR	NR
3/5/03	2.97	19.7	687	NR	NR
3/25/03	2.00	32.3	2420	61.1	65.0
5/1/03	1.73	38.0	>2420	>61.1	>65.0
6/17/03	41.29	0.5	>2420	>61.1	>65.0
90th Percentile Concentration			>2420	>61.1	>65.0

- Notes:
1. NR = No reduction required.
 2. 30-day Geometric Mean could not be calculated due to insufficient data.
 3. Reductions for individual samples (shaded area) is included for reference only.

Table C-13 Required Load Reduction for Weaver Branch

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (941 CFU/100 ml)	Sample to Target - MOS (847 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
9/19/02	0.20	100.0	>2420	>61.1	>65.0
10/17/02	0.44	85.3	1733	45.7	51.1
11/26/02	2.09	35.0	548	NR	NR
12/17/02	3.35	20.9	387	NR	NR
1/22/03	1.65	43.5	548	NR	NR
3/5/03	3.38	20.5	649	NR	NR
3/25/03	2.30	31.7	167	NR	NR
4/30/03	2.32	31.3	548	NR	NR
6/17/03	44.76	0.4	687	NR	NR
90th Percentile Concentration			>1870	>49.7	>54.7

- Notes:
1. NR = No reduction required.
 2. 30-day Geometric Mean could not be calculated due to insufficient data.
 3. Reductions for individual samples (shaded area) is included for reference only.

Table C-14 Required Load Reduction for Back Creek at BACK000.5SU

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (941 CFU/100 ml)	Sample to Target - MOS (847 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
9/9/99	1.94	87.4	866	NR	2.2
7/17/02	1.36	94.7	>2419	>61.1	>65.0
8/20/02	1.11	97.8	1300	27.6	34.8
9/11/02	0.87	99.9	727	NR	NR
10/23/02	1.65	91.6	1733	45.7	51.1
11/13/02	33.79	10.4	1553	39.4	45.5
12/3/02	7.66	46.9	866	NR	2.2
1/15/03	8.68	42.8	548	NR	NR
2/18/03	43.16	8.0	326	NR	NR
3/12/03	13.40	27.1	29	NR	NR
4/15/03	23.02	15.2	411	NR	NR
5/12/03	13.02	28.2	816	NR	NR
6/25/03	10.52	35.3	921	NR	8.0
90th Percentile Concentration			>1697	>44.6	>50.1

Notes: 1. NR = No reduction required.
2. 30-day Geometric Mean could not be calculated due to insufficient data.
3. Reductions for individual samples (shaded area) is included for reference only.

Table C-15 Required Load Reduction for Beaver Creek at BEAVE001.0SU

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (941 CFU/100 ml)	Sample to Target - MOS (847 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
3/3/98	55.66	53.8	299	NR	NR
6/25/98	107.65	28.5	>2419	>61.1	>65.0
9/17/98	11.34	97.4	24	NR	NR
12/15/98	50.07	57.8	1120	16.0	24.4
3/2/99	96.94	31.9	179	NR	NR
6/15/99	18.67	88.0	249	NR	NR
9/7/99	26.03	80.1	11	NR	NR
12/2/99	27.80	78.4	166	NR	NR
2/17/00	81.30	38.7	89	NR	NR
5/11/00	39.25	66.8	152	NR	NR
8/10/00	91.06	34.5	2419	61.1	65.0
11/28/00	16.51	90.9	517	NR	NR
3/7/01	94.78	33.0	249	NR	NR
6/26/01	167.86	16.6	144	NR	NR
7/17/01	47.81	59.5	5	NR	NR
10/9/01	37.30	68.8	285	NR	NR
4/16/02	45.90	61.0	299	NR	NR
7/17/02	12.91	95.4	727	NR	NR
8/20/02	29.27	76.8	1553	39.4	45.5
9/11/02	7.88	100.0	185	NR	NR
10/23/02	14.64	93.3	461	NR	NR
11/13/02	357.66	5.3	>2419	>61.1	>65.0
12/3/02	58.29	52.1	649	NR	NR
1/15/03	68.11	45.9	17	NR	NR
2/18/03	427.02	4.1	687	NR	NR
3/12/03	112.14	27.1	345	NR	NR
4/15/03	275.17	8.4	770	NR	NR
5/12/03	144.20	20.2	1203	21.8	29.6
6/25/03	107.38	28.6	866	NR	2.2R
8/12/03	425.06	4.1	>2419	>61.1	>65.0
11/4/03	38.87	67.1	130	NR	NR
8/4/04	87.30	36.0	1414	33.5	40.1
11/4/04			2000	53.0	57.7
90th Percentile Concentration			>2335	>59.7	>63.7

- Notes: 1. NR = No reduction required.
2. 30-day Geometric Mean could not be calculated due to insufficient data.
3. Reductions for individual samples (shaded area) is included for reference only.

Table C-16 Required Load Reduction for Beaver Creek at BEAVE015.3SU

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (941 CFU/100 ml)	Sample to Target - MOS (847 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
3/3/98	17.37	54.8	548	NR	NR
6/25/98	33.44	31.5	1553	39.4	45.5
9/17/98	3.65	96.9	>2419	>61.1	>65.0
12/15/98	17.45	54.6	1046	10.0	19.0
3/2/99	30.75	34.0	326	NR	NR
6/15/99	6.05	86.4	1046	10.0	19.0
9/7/99	7.37	81.5	1414	33.6	40.1
12/2/99	9.41	75.3	461	NR	NR
2/17/00	26.32	39.6	1046	10.0	19.0
5/11/00	12.41	66.5	1553	39.4	45.5
8/10/00	31.00	33.7	1986	52.6	57.4
11/28/00	5.15	90.4	308	NR	NR
3/7/01	29.93	35.2	1553	39.4	45.5
6/26/01	53.80	17.7	1300	27.6	34.8
7/17/01	15.44	58.7	613	NR	NR
10/9/01	11.92	68.0	>2419	>61.1	>65.0
4/16/02	14.55	60.8	>2419	>61.1	>65.0
7/17/02	4.05	95.3	>2419	>61.1	>65.0
8/20/02	8.40	78.5	>2419	>61.1	>65.0
9/11/02	2.56	100.0	>2419	>61.1	>65.0
10/23/02	4.75	92.6	>2419	>61.1	>65.0
11/13/02	119.04	5.7	2419	61.1	65.0
12/3/02	19.29	50.7	>2419	>61.1	>65.0
1/15/03	21.86	46.8	144	NR	NR
2/18/03	135.66	4.7	649	NR	NR
3/12/03	35.34	29.2	1733	45.7	51.1
4/15/03	85.71	9.3	1986	52.6	57.4
5/12/03	44.71	22.4	>2419	>61.1	>65.0
6/25/03	33.86	30.9	>2419	>61.1	>65.0
8/12/03	131.75	4.8	>2419	>61.1	>65.0
11/4/03	12.58	66.1	2419	61.1	65.0
8/4/04	27.17	38.5	>2419	>61.1	>65.0
11/4/04			2600	63.8	67.4
90th Percentile Concentration			>2419	>61.1	>65.0

- Notes: 1. NR = No reduction required.
2. 30-day Geometric Mean could not be calculated due to insufficient data.
3. Reductions for individual samples (shaded area) is included for reference only.

Table C-17 Required Load Reduction for Cedar Creek

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (941 CFU/100 ml)	Sample to Target - MOS (847 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
9/9/99	1.31	90.0	980	4.0	13.6
7/17/02	1.04	94.7	548	NR	NR
8/20/02	2.17	78.4	770	NR	NR
9/11/02	0.65	99.9	770	NR	NR
10/23/02	1.13	93.4	1414	33.6	40.1
11/13/02	25.38	9.9	921	NR	8.0
12/3/02	4.59	56.2	387	NR	NR
1/15/03	5.47	49.7	770	NR	NR
2/18/03	31.97	7.0	1300	27.6	34.8
3/12/03	8.91	33.2	31	NR	NR
4/15/03	20.83	12.8	313	NR	NR
5/12/03	10.71	27.8	687	NR	NR
6/25/03	8.25	36.2	308	NR	NR
90th Percentile Concentration			1236	23.9	31.5

- Notes:
1. NR = No reduction required.
 2. 30-day Geometric Mean could not be calculated due to insufficient data.
 3. Reductions for individual samples (shaded area) is included for reference only.

Table C-18 TMDLs, WLAs, & LAs for South Fork Holston River Watershed

HUC-12 Subwatershed (06010102__) or Drainage Area	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	WLAs				LAs ^d
				WWTFs ^a		Leaking Collection Systems ^b	MS4s ^c	
				Monthly Avg.	Daily Max.			
			[% Red.]	[CFU/day]	[CFU/day]	[CFU/day]	[% Red.]	[% Red.]
0104 (DA)	Waters Branch	TN060101020250 – 0900	>79.9	NA	NA	NA	>81.9	>81.9
0104 (DA)	Laurel Creek	TN060101020250 – 2000	>79.9	NA	NA	NA	>81.9	>81.9
0302 (DA)	Painter Springs Branch	TN060101020540 – 0800	>61.1	NA	NA	NA	>65.0	>65.0
0401	Unnamed Trib to South Fork Holston River	TN06010102012 – 0300	>61.1	NA	NA	NA	>65.0	>65.0
	Morrell Creek	TN06010102012 – 0400	>79.9	NA	NA	NA	>81.9	>81.9
0402 (DA)	Unnamed Trib to South Fork Holston River	TN06010102012 – 0100	>45.2	NA	NA	NA	>50.6	>50.6
0402 (DA)	Big Arm Branch	TN06010102012 - 0810	>79.9	NA	NA	NA	>81.9	>81.9
0402 (DA)	Dry Creek	TN06010102012 - 0700	>61.1	NA	NA	NA	>65.0	>65.0
0402 (DA)	Woods Branch	TN06010102012 - 0820	34.5	NA	NA	NA	41.1	41.1
0403	Candy Creek	TN06010102006T – 0300	>54.6	NA	NA	NA	>59.1	>59.1
	Wagner Creek	TN06010102006T – 0200	>61.1	1.669x10 ⁸	1.247x10 ⁹	NA	>65.0	>65.0
	Weaver Branch	TN06010102012 – 0900	>49.7	NA	NA	NA	>54.7	>54.7

Table C-18(cont'd) TMDLs, WLAs, & LAs for South Fork Holston River Watershed

HUC-12 Subwatershed (06010102__) or Drainage Area	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	WLAs				LAs ^d
				WWTFs ^a		Leaking Collection Systems ^b	MS4s ^c	
				Monthly Avg.	Daily Max.			
			[% Red.]	[CFU/day]	[CFU/day]	[CFU/day]	[% Red.]	[% Red.]
0502	Back Creek	TN06010102042 – 0200	>44.6	2.861x10 ⁷	2.137x10 ⁸	0	>50.1	>50.1
	Beaver Creek	TN06010102042 – 1000	>59.7	1.431x10 ⁷	1.069x10 ⁸	0	>63.7	>63.7
	Beaver Creek	TN06010102042 – 2000 ^e	>61.1	NA	NA	0	>65.0	>65.0
	Cedar Creek	TN06010102042 – 0500	23.9	NA	NA	0	31.5	31.5

Notes: NA = Not Applicable.

- a. Future WWTFs must meet instream water quality standards at the point of discharge as specified in their NPDES permit.
- b. Pathogen loading due to collection system failure is considered to be unpermitted point source loading from the municipal WWTF. With respect to pathogen loading from leaking collection systems, a WLA of zero is assigned. It is recognized, however, that a WLA of 0 CFU/day may not be practical. For these unpermitted sources, the WLA is interpreted to mean a reduction in pathogen loading to the maximum extent practicable, consistent with the requirement that these sources not contribute to a violation of the water quality standard for E. coli.
- c. Applies to any MS4 discharge loading in the subwatershed or drainage area.
- d. The load allocations (LAs) listed apply to precipitation induced nonpoint sources only. The objective for all “other direct sources” (leaking septic systems, illicit discharges, and animals access to streams) is a LA of zero. It is recognized, however, that for leaking septic systems a LA of 0 CFU/day may not be practical. For these unpermitted sources, the LA is interpreted to mean a reduction in E. coli loading to the maximum extent practicable, consistent with the requirement that these sources not contribute to a violation of the water quality standard for E. coli.
- e. Portions of these waterbodies lie in another state. A TMDL for Fecal Coliform has been developed by the State of Virginia for those portions of the waterbodies lying within their jurisdiction. The required load reduction is for the Tennessee portion of the waterbodies.

APPENDIX D

Hydrodynamic Modeling Methodology

HYDRODYNAMIC MODELING METHOD

D.1 Model Selection

The Loading Simulation Program C++ (LSPC) was selected for flow simulation of pathogen-impaired waters in the subwatersheds of the South Fork Holston River Watershed. LSPC is a watershed model capable of performing flow routing through stream reaches. LSPC is a dynamic watershed model based on the Hydrologic Simulation Program - Fortran (HSPF)

D.2 Model Set Up

The South Fork Holston River Watershed was delineated into subwatersheds in order to facilitate model hydrologic calibration. Boundaries were constructed so that subwatershed “pour points” coincided with HUC-12 delineations, 303(d)-listed waterbodies, and water quality monitoring stations. Watershed delineation was based on the NHD stream coverage and Digital Elevation Model (DEM) data. This discretization facilitates simulation of daily flows at water quality monitoring stations.

Several computer-based tools were utilized to generate input data for the LSPC model. The Watershed Characterization System (WCS), a geographic information system (GIS) tool, was used to display, analyze, and compile available information to support hydrology model simulations for selected subwatersheds. This information includes land use categories, point source dischargers, soil types and characteristics, population data (human and livestock), and stream characteristics.

An important factor influencing model results is the precipitation data contained in the meteorological data files used in these simulations. Weather data from multiple meteorological stations were available for the time period from January 1970 through August 2004. Meteorological data for a selected 11-year period were used for all simulations. The first year of this period was used for model stabilization with simulation data from the subsequent 10-year period (10/1/94 – 9/30/04) used for TMDL analysis.

D.3 Model Calibration

Hydrologic calibration of the watershed model involves comparison of simulated streamflow to historic streamflow data from U. S. Geological Survey (USGS) stream gaging stations for the same period of time. Two USGS continuous record stations located near the South Fork Holston River Watershed with a sufficiently long and recent historical record was selected as the basis of the hydrology calibration. The USGS station was selected based on similarity of drainage area, Level IV ecoregion, land use, and topography. The calibration involved comparison of simulated and observed hydrographs until statistical stream volumes and flows were within acceptable ranges as reported in the literature (Lumb, et al., 1994).

Initial values for hydrologic variables were taken from an EPA developed default data set. During the calibration process, model parameters were adjusted within reasonable constraints until acceptable agreement was achieved between simulated and observed streamflow. Model parameters adjusted include: evapotranspiration, infiltration, upper and lower zone storage, groundwater storage, recession, losses to the deep groundwater system, and interflow discharge.

The results of the hydrologic calibration for Watauga River near Sugar Grove, North Carolina, USGS Station 03479000, ecoregion 66, are shown in Table D-1 and Figures D-1 and D-2. The results of the hydrologic calibration for Bullrun Creek near Halls Crossroads, Tennessee, USGS Station 03535000, ecoregion 67, are shown in Table D-2 and Figure D-3 and D-4.

Table D-1. Hydrologic Calibration Summary: Watauga River (USGS 03479000)

		90.03685086	
Simulation Name:	USGS034679000	Simulation Period:	
		Watershed Area (ac):	57642.03
Period for Flow Analysis			
Begin Date:	10/01/90	Baseflow PERCENTILE:	2.5
End Date:	09/30/00	Usually 1%-5%	
Total Simulated In-stream Flow:	279.14	Total Observed In-stream Flow:	287.45
Total of highest 10% flows:	112.83	Total of Observed highest 10% flows:	119.65
Total of lowest 50% flows:	51.31	Total of Observed Lowest 50% flows:	52.05
Simulated Summer Flow Volume (months 7-9):	38.04	Observed Summer Flow Volume (7-9):	37.10
Simulated Fall Flow Volume (months 10-12):	57.06	Observed Fall Flow Volume (10-12):	54.65
Simulated Winter Flow Volume (months 1-3):	109.31	Observed Winter Flow Volume (1-3):	115.74
Simulated Spring Flow Volume (months 4-6):	74.73	Observed Spring Flow Volume (4-6):	79.96
Total Simulated Storm Volume:	240.50	Total Observed Storm Volume:	245.38
Simulated Summer Storm Volume (7-9):	28.28	Observed Summer Storm Volume (7-9):	26.59
<i>Errors (Simulated-Observed)</i>		<i>Recommended Criteria</i>	Last run
Error in total volume:	-2.89	10	
Error in 50% lowest flows:	-1.43	10	
Error in 10% highest flows:	-5.70	15	
Seasonal volume error - Summer:	2.54	30	
Seasonal volume error - Fall:	4.40	30	
Seasonal volume error - Winter:	-5.56	30	
Seasonal volume error - Spring:	-6.53	30	
Error in storm volumes:	-1.99	20	
Error in summer storm volumes:	6.38	50	
Criteria for Median Monthly Flow Comparisons			
Lower Bound (Percentile):	25		
Upper Bound (Percentile):	75		

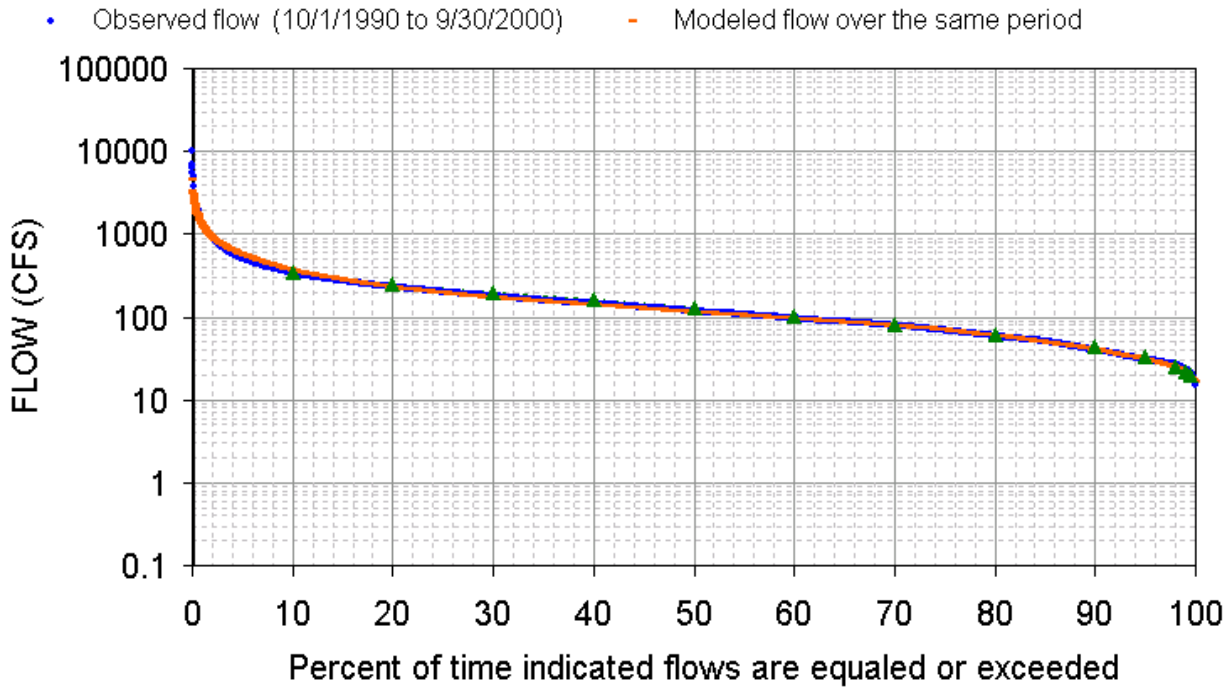


Figure D-1. Hydrologic Calibration: Watauga River, USGS 03479000)

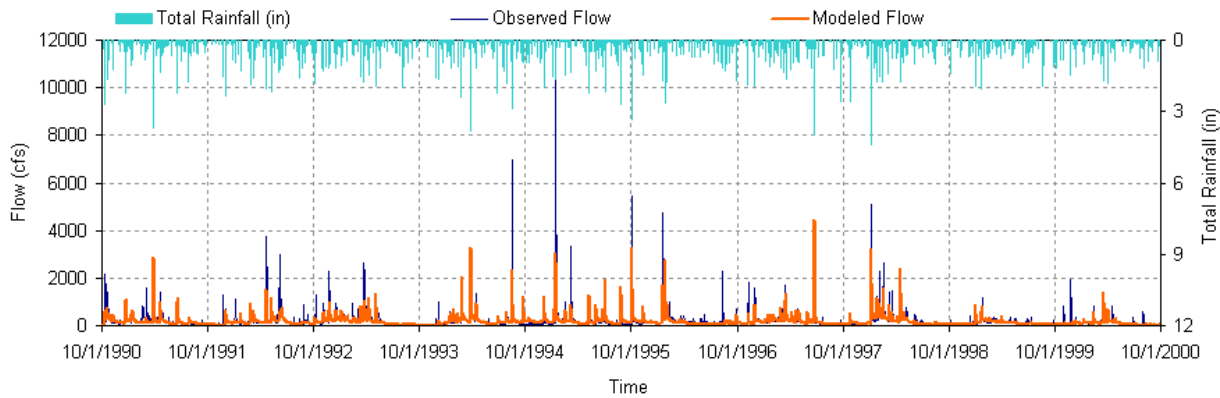


Figure D-2. 10-Year Hydrologic Comparison: Watauga River at Belleview, USGS 03479000

Table D-2. Hydrologic Calibration Summary: Bullrun Creek (USGS 03535000)

Simulation Name:		USGS03535000		Simulation Period:			
Period for Flow Analysis				Watershed Area (ac):		43607.17	
Begin Date:		10/01/80		Baseflow PERCENTILE:		2.5	
End Date:		09/30/86		<i>Usually 1%-5%</i>			
Total Simulated In-stream Flow:		82.36		Total Observed In-stream Flow:		91.27	
Total of highest 10% flows:		42.83		Total of Observed highest 10% flows:		47.36	
Total of lowest 50% flows:		9.68		Total of Observed Lowest 50% flows:		10.06	
Simulated Summer Flow Volume (months 7-9):		9.30		Observed Summer Flow Volume (7-9):		7.91	
Simulated Fall Flow Volume (months 10-12):		14.00		Observed Fall Flow Volume (10-12):		15.95	
Simulated Winter Flow Volume (months 1-3):		31.45		Observed Winter Flow Volume (1-3):		35.49	
Simulated Spring Flow Volume (months 4-6):		27.61		Observed Spring Flow Volume (4-6):		31.92	
Total Simulated Storm Volume:		76.18		Total Observed Storm Volume:		83.16	
Simulated Summer Storm Volume (7-9):		7.76		Observed Summer Storm Volume (7-9):		5.88	
Errors (Simulated-Observed)				Recommended Criteria		Last run	
Error in total volume:		-9.76		10			
Error in 50% lowest flows:		-3.75		10			
Error in 10% highest flows:		-9.57		15			
Seasonal volume error - Summer:		17.59		30			
Seasonal volume error - Fall:		-12.22		30			
Seasonal volume error - Winter:		-11.39		30			
Seasonal volume error - Spring:		-13.50		30			
Error in storm volumes:		-8.39		20			
Error in summer storm volumes:		31.99		50			

Criteria for Median Monthly Flow Comparisons

Lower Bound (Percentile): **25**
Upper Bound (Percentile): **75**

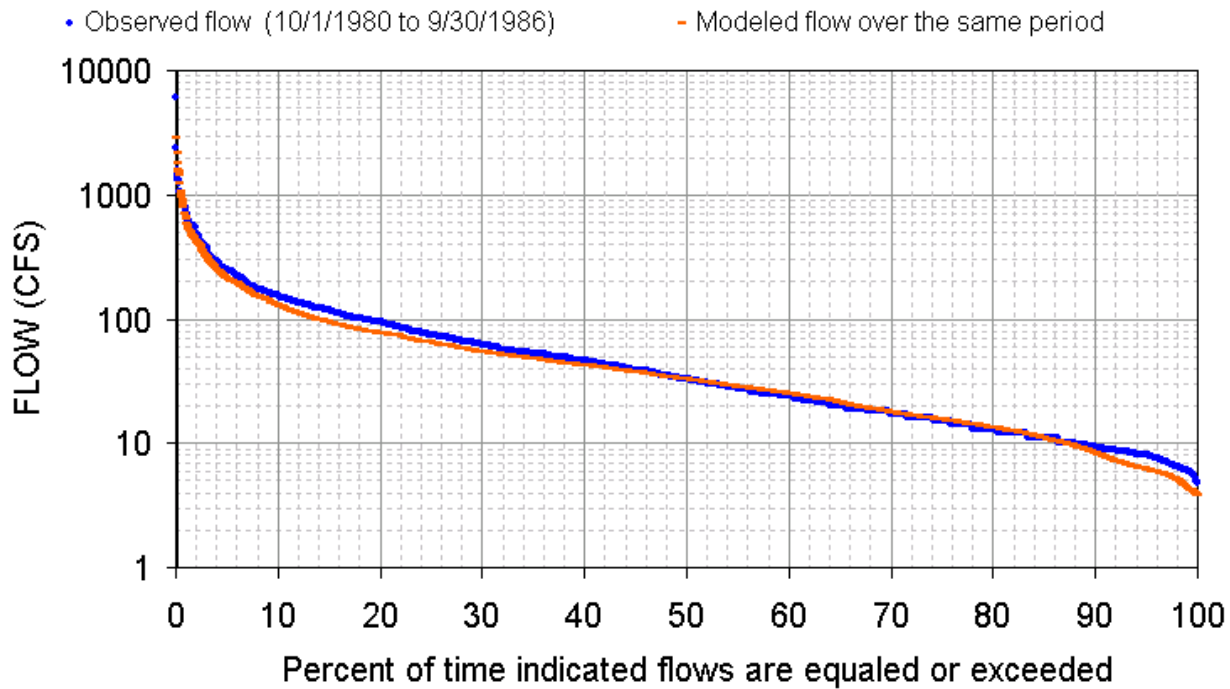


Figure D-3. Hydrologic Calibration: Bullrun Creek, USGS 03535000

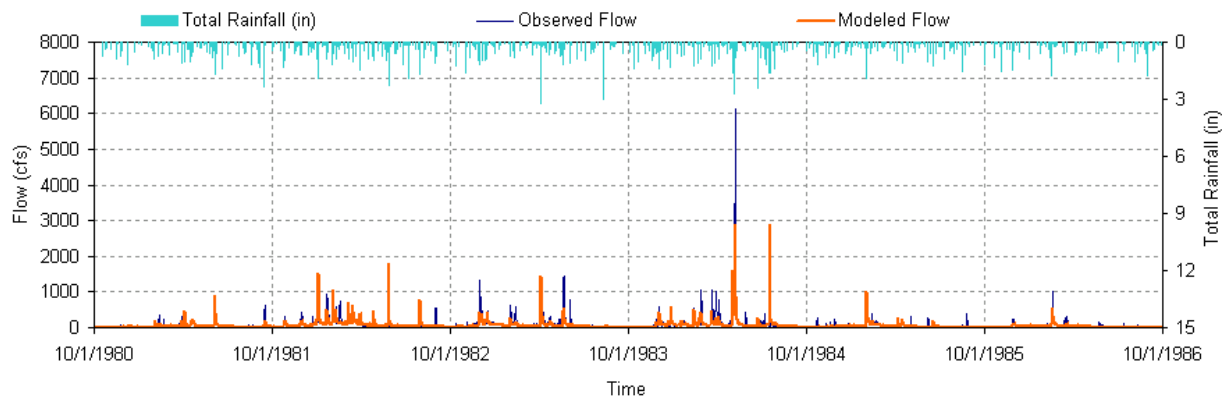


Figure D-4. 6-Year Hydrologic Comparison: Bullrun Creek, USGS 03535000